July 7, 1970 J. H. LEVINE ET AL 3,519,183

SINGLE CAPSTAN MAGNETIC TAPE TRANSPORT

Filed Oct. 7, 1968 2 Sheets-Sheet 1

Fig. 1.

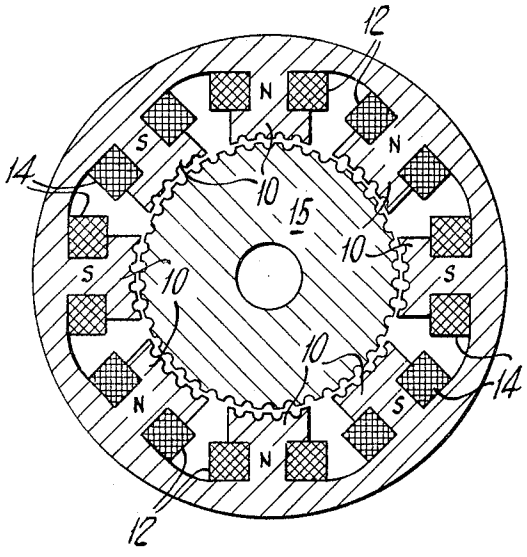


Fig. 4.

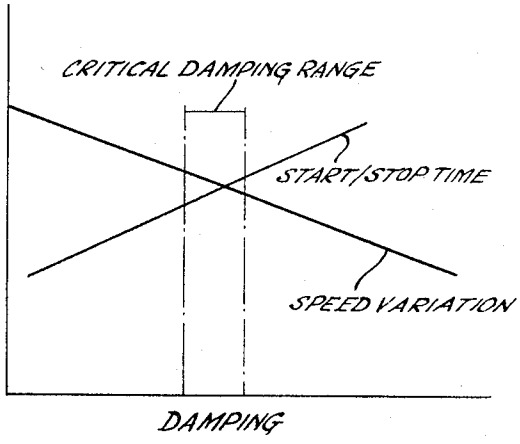
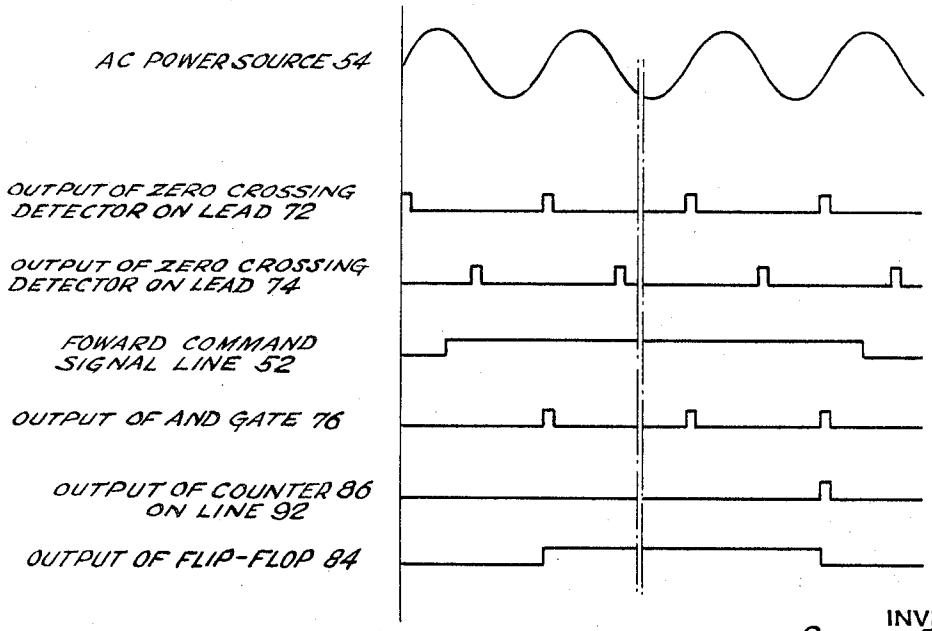


Fig. 3.



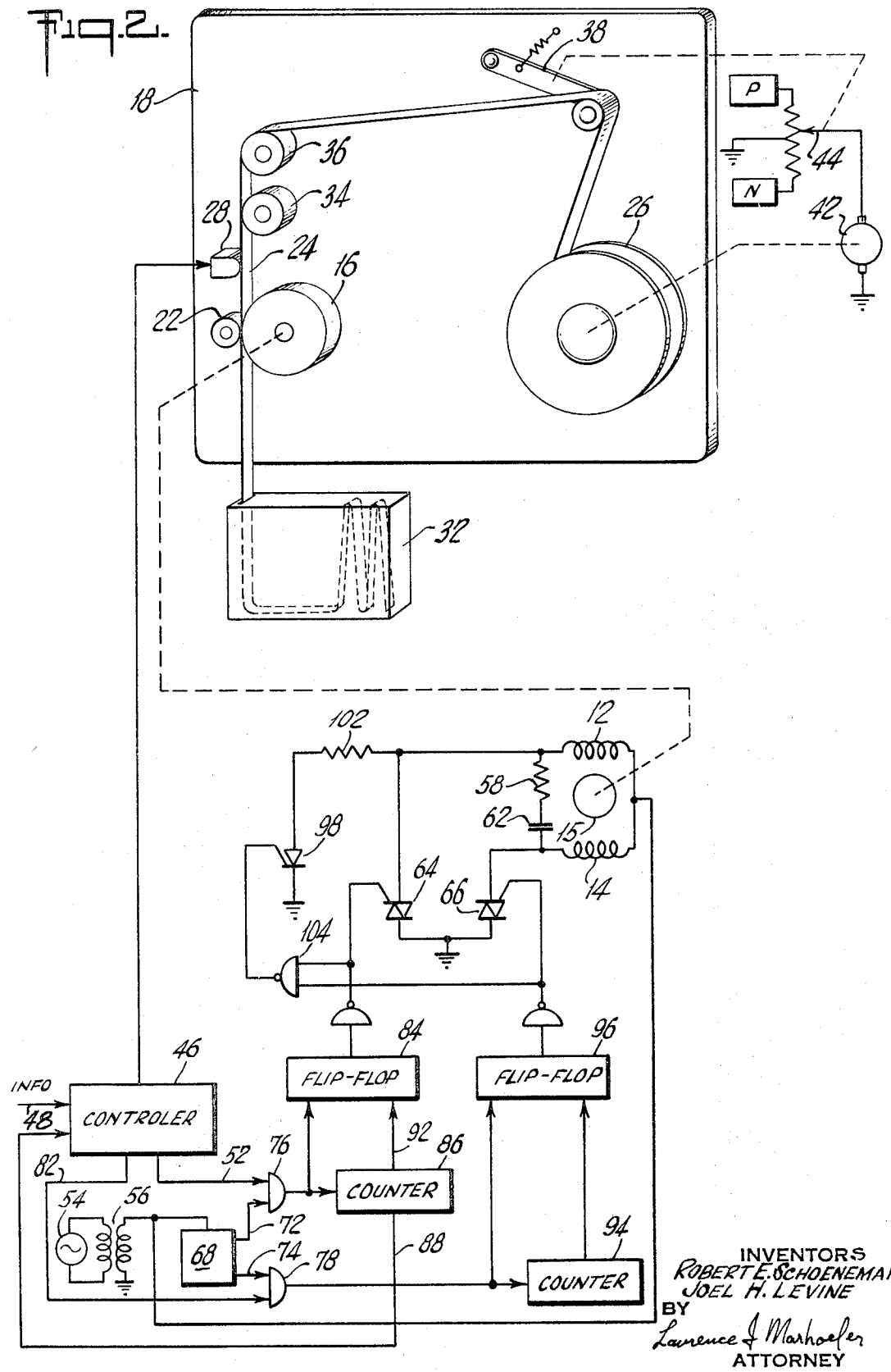
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Fig. 2.



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SINGLE CAPSTAN MAGNETIC TAPE TRANSPORT

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U.S. Cl. 226—49 6 Claims

ABSTRACT OF THE DISCLOSURE

The specification and drawings disclose a transport for bi-directionally driving magnetic information storage tape through a fixed distance by means of a single capstan driven by a synchronous inductor motor which is coupled to an A.C. power supply for a predetermined number of A.C. cycles.

BACKGROUND OF THE INVENTION

This invention relates to a magnetic tape transport and, more particularly, to a single capstan transport that is simple in its design and inexpensive in its manufacture.

A so-called single capstan transport, as the term is used by those skilled in the art, is one in which the tape continuously engages a capstan driven by either a low inertia motor directly coupled to the capstan or by a continuously rotating motor coupled to the capstan by a clutch-brake system. An example of a single capstan transport employing a directly coupled low inertia motor is disclosed in U.S. Pat. No. 2,708,554, issued in the names of H. F. Welsh et al. on May 17, 1955.

With the advent of improved low inertia motors, such directly-driven single capstan transports have proved generally satisfactory. However, they are relatively expensive because of the relatively expensive electronic control systems required for rapidly starting and stopping the motor and/or running it at a constant speed.

One object of this invention is the provision of a simple, inexpensive, directly-driven single capstan transport which is capable of recording and reading information in an industry compatible format.

Another object of this invention is the provision of a simple inexpensive magnetic tape transport which can translate the tape a predetermined distance in response to a command signal. Such transports are particularly useful in direct data entry applications in which information received at an asynchronous rate is stored in a buffer and then recorded on the tape in a blocked format.

A still further object of the invention is the provision of an inexpensive directly-driven single capstan transport for operation at low tape speeds. At low tape speeds even a small change in actual speed is a relatively large change in terms of percentage variation from rated speed. As will be understood by those skilled in the art, in order to record in an industry compatible format, the tape speed cannot vary more than about plus or minus five percent of its nominal value.

SUMMARY OF THE INVENTION

Briefly, this invention contemplates the provision of a single capstan transport in which the capstan is driven by a directly coupled synchronous inductor motor. Critical damping of the capstan and motor keeps capstan speed variations within allowable limits while permitting sufficiently rapid starting and stopping of the tape to record in an industry compatible format. The motor is powered from alternating current (A.C.) power source, and tape is translated through a fixed distance by coupling the motor to the source for a predetermined integral number of A.C. half cycles.

BRIEF DESCRIPTION OF THE DRAWINGS

Having briefly described this invention, it will be described in greater detail along with other objects and advantages in the following detailed description of a preferred embodiment which may be best understood by reference in the accompanying drawings. These drawings form part of the instant specification and are to be read in conjunction therewith. Like reference numerals are used to indicate like parts in the various views;

FIG. 1 is a sectional view of a synchronous inductor motor.

FIG. 2 is a schematic view of a magnetic tape transport constructed in accordance with the teachings of this invention.

FIG. 3 is a timing diagram showing the instantaneous relationship among signals at various indicated locations in FIG. 2.

FIG. 4 is a picture of the relationship among damping, starting and stopping times, and capstan speed variations for a transport constructed in accordance with the teachings of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1 of the drawings, one example of a motor employed in the practice of this invention is the synchronous inductor motor which is described in detail in an article entitled "Characteristics of a Synchronous Inductor Motor" by Arthur E. Snowdon and Elmer W. Madsen. This article appeared in the March 1962 issue of Applications and Industry, published by the American Institute of Electrical Engineers. Briefly, in a specific embodiment of this invention that has proved satisfactory, the motor has eight salient poles **10** with a two-phase, four-pole winding. Coils marked **12** are interconnected to form one phase of the winding and coils marked **14** are interconnected and form the second phase. A permanent magnet rotor **15** has a series of tooth projections around its entire periphery which interact with similar tooth projections on the pole pieces **10** providing a variable reluctance air gap which induces a synchronizing voltage even though the rotor **15** is turning slowly. The rotor **15** is so constructed that its entire periphery is a south pole.

In this exemplary embodiment of the invention, the stator tooth pitch is 48 teeth for a full circle although there are only 40 actual teeth, one tooth per pole being omitted to allow space for the windings **12** and **14**. The rotor tooth pitch is 50 teeth for a full circle; the rotor will advance one tooth for each complete cycle of applied alternating current (A.C.) power. The synchronous speed of this motor is 72 r.p.m. at 60 Hz. supply frequency. In general, the synchronous speed of such motors may be determined from the formula:

$$S=60f/n$$

where;

S=r.p.m. of rotor,
n=number of rotor teeth,
f=frequency of supply voltage.

It will be appreciated that the motor attains synchronous speed in approximately one cycle of the energizing potential and that owing to the permanent magnet rotor, it stops with a distance equal to a tooth pitch when the energizing potential is removed.

Referring now to FIG. 2, the rotor **15** is directly coupled to a capstan **16** rotatably mounted on base plate **18**. A roller **22** presses a magnetic tape **24** into continuous engagement with the capstan **16** while information is being recorded on or read from the tape; the roller **22** is retractable so that the tape may be rewound independently

of the capstan. The tape **24** is stored on a reel **26** on one side of a transducer **28** and is driven by the capstan **16** past the transducer **28** and into a storage bin **32** on the other side of the transducer. Stationary guides **34** and **36** guide the tape so that it passes at right angles to the head **28**.

A spring loaded rocker arm **38** tensions the tape **24** and controls a reel servo motor **42** which drives the reel **26**. To control the motor **42**, the rocker arm **38** is coupled to a potentiometer wiper arm **44** whose output is coupled to the reel servo motor **42**. The motor **42** is thusly energized so as to cause the reel **26** to pay out and take up the tape **24**, depending upon the position of the arm **38**.

The specific embodiment of the invention shown in FIG. 2 has particular application as a direct entry to magnetic tape information storage device. Information received by a controller **46** on a line **48** from a keyboard, for example, is stored in a suitable buffer in the controller **46** such as a ferrite core buffer. When a predetermined number of binary bits has been stored, the controller **46** generates a tape advance signal which appears on line **52**; in response to this signal the capstan **16** advances the tape **24** through a fixed distance past the head **28** as will be described now in detail.

One side of the windings **12** and **14** are coupled to an A.C. power source **54** via a transformer **56**. Preferably, the power supply **54** is the so-called A.C. house current, which is advantageous because it provides a constant frequency supply and eliminates the need for (and the cost of) a special power supply. A phase-shifting network comprising resistor **58** and capacitor **62** causes the windings **12** and **14** to be energized 90 degrees out of phase with respect to one another.

The other side of the windings **12** and **14** are connected to ground via triacs **64** and **66** respectively. Two triacs are used in order to provide bi-directional rotation of the rotor **15**; conduction through triac **64** producing clockwise rotation of the rotor, for example, and conduction through triac **66** producing counter-clockwise rotation of the rotor **15**. As will be appreciated by those skilled in the art, a triac is a silicon semiconductor device that is similar to a silicon control rectifier but the triac is capable of bi-directional conduction. These devices are explained in detail in various manufacturers' manuals, such as the R.C.A. Silicon Power Circuits Manual, prepared by the R.C.A. Electronic Components & Devices Division of Harrison, N.J.

Referring now to FIG 3 as well as FIG. 2, the transformer **56** is also coupled to a zero crossing detector **68** which generates a pulse on line **72** for each positive going crossing of the sine wave and a pulse on line **74** for each negative going crossing of the sine wave. Lines **72** and **74** are coupled respectively as inputs to AND gates **76** and **78**; the enabling inputs to these gates are coupled to the controller via lines **52** and **82** respectively.

Aa tape advance command signal on line **52** subsists for an interval sufficient to advance the tape one block length, for example, and enables gate **76** so that pulses on line **72** during this interval are coupled both to a flip-flop **84** and a counter **86**. The first pulse sets flip-flop **84** and thereby turns on triac **64**. The rotor **15** accelerates in a counter-clockwise sense, driving capstan **16** in the same sense and thereby advancing tape **24** past the head **28**. After one complete cycle of A.C. power has been applied to windings **12** and **14**, the rotor **15** is rotating at synchronous speed. At this time counter **86** will have counted two pulses and will produce an output on line **88** which signals the controller **46** that the tape **24** is up to speed. Information stored in the buffer now may be coupled to the head **28**.

After a predetermined number of pulses have been counted by the counter **86** (five for example), the counter **86** produces an output on line **92** that resets the flip-flop **84** to its other stable state and thereby turns off triac **64**. The tape **24** will have been driven through a fixed distance which is a function of the predetermined number of pulses counted by counter **86** prior to turning off triac **64** and of the tooth pitch of the rotor **15**.

In a similar manner the capstan **16** can be driven in a clockwise sense to retract a fixed length of tape in order to position a just previously recorded information block so that it can be read and thereby compared with the information stored in the buffer to check that the information was correctly recorded. To this end, the output of AND gate **78** is coupled to a flip-flop **96** and a counter **94** which cooperate to turn on and off triac **66** in the manner just previously described for the clockwise rotation of rotor **15**.

The permanent magnet rotor **15** stops and locks in position within the pitch of one tooth after triac **64** or **66** has turned off. However, it is sometimes advantageous to provide an additional locking force to prevent rotation of the tape capstan due to tape tension. Passing a D.C. current through the winding **12** or **14** after the triacs **64** and **66** have stopped conducting provides such an additional locking force. To provide this D.C. current, a silicon control rectifier **98** is coupled via a current limiting resistor **102** in series between the coil **12** and ground. When both flip-flops **84** and **96** are in their first stable state, both triacs are off, an output from an AND gate **104** turns on SCR**98**.

The speed of the synchronous inductor motor oscillates about its synchronous speed; these oscillatory speed variations may exceed the permissible speed variations required for writing industry compatible magnetic tapes. As graphically indicated in FIG. 4, such speed variations decrease with increased damping of the capstan and motor. However, as also graphically indicated in FIG. 4, the time for starting and stopping the capstan increases with increased damping. Thusly, the motor and capstan must be so damped that any speed variations are within allowable limits but must not be overdamped, preventing starting and stopping of the capstan within allowable distances.

Any suitable damping known in the art may be employed, including electronic damping. One particularly advantageous system is to use in combination a relatively high inertia capstan **16** and to fill the gap between the rotor **15** and the poles **10** with a viscose fluid, such as a silicon oil.

Thus, it will be seen that the objects of this invention have been accomplished. The use of a directly coupled synchronous inductor motor provides a simple, inexpensive directly driven single capstan transport which is capable of low speed operation and can translate the tape through a fixed distance without expensive and elaborate control circuitry.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims. It is further obvious that various changes may be made in details within the scope of the claims without departing from the spirit of the invention. It is, therefore, to be understood that this invention is not to be limited to the specific details shown and described.

What is claimed is:

1. A magnetic tape transport for moving a magnetic tape bi-directionally through a predetermined distance in response to a command, comprising in combination:

a capstan for driving said magnetic tape,

a synchronous motor directly coupled to said capstan for driving said capstan,

means including counter means for coupling said motor to an alternating power supply for a predetermined number of alternating current cycles to rotate the periphery of said capstan through a predetermined distance whereby said magnetic tape is driven a predetermined distance.

2. A magnetic tape transport as in claim 1 wherein said synchronous motor is a synchronous inductor motor.

3. A magnetic tape transport as in claim 2 wherein said coupling means includes a phase-splitting means for energizing said motor for bi-directional rotation, and wherein said counter means couples said motor to said alternating current power supply for a greater number of predetermined alternating current cycles when advancing said tape as compared with the number of alternating current cycles when retracting said tape.

4. A magnetic tape transport as in any one of claims 1, 2, and 3 further including means responsive to the output of said counter means for energizing said motor with a holding current when said motor is unenergized for forward or reverse movement.

5. A magnetic tape transport as in claim 2 or 3 further including a zero crossing detector, means for coupling the output of said zero crossing detector to said counter, and means for coupling the input of said zero crossing detector to said alternating current power input means.

6. A magnetic tape transport as in claims 2 or 3 further including means for critically damping said motor and said capstan.

References Cited

UNITED STATES PATENTS

3,389,843	6/1968	Touchman	226—156
3,425,613	2/1969	Reisfeld	226—188 X

RICHARD A. SCHACHER, Primary Examiner

U.S. Cl. X.R.

226—134, 152; 318—10, 138